Intel® 925X and 925XE Express Chipset

Thermal Design Guide

For the Intel® 82925X/82925XE Memory Controller Hub (MCH)

November 2004

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Contents

Figures

Tables

Revision History

Revision Number	Description	Revision Date
-001	• Initial Release.	June 2004
-002	• Updated Table 3-1, MCH Thermal Specifications	June 2004
-003	• Added 82925XE MCH.	November 2004

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1 Introduction

As the complexity of computer systems increases, so do the power dissipation requirements. Care must be taken to ensure that the additional power is properly dissipated. Typical methods to improve heat dissipation include selective use of ducting, and/or passive heatsinks.

The goals of this document are to:

- Outline the thermal and mechanical operating limits and specifications for the Intel® 82925X/82925XE Memory Controller Hub (MCH).
- Describe a reference thermal solution that meets the specification of the 82925X/82925XE MCH.

Properly designed thermal solutions provide adequate cooling to maintain the MCH die temperatures at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the die to local-ambient thermal resistance. By maintaining the MCH die temperature at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the chipset. Operation outside the functional limits can degrade system performance and may cause permanent changes in the operating characteristics of the component.

The simplest and most cost effective method to improve the inherent system cooling characteristics is through careful design and placement of fans, vents, and ducts. When additional cooling is required, component thermal solutions may be implemented in conjunction with system thermal solutions. The size of the fan or heatsink can be varied to balance size and space constraints with acoustic noise.

This document addresses thermal design and specifications for the 82925X/82925XE MCH component only. For thermal design information on other chipset components, refer to the respective component datasheet. For the ICH6, refer to the *Intel® I/O Controller Hub 6 (ICH6) Thermal Design Guide*.

Note: Unless otherwise specified, the term ICH6 refers to the Intel® 82801FB ICH6 and 82801FR ICH6R I/O Controller Hubs.

1.1 Definition of Terms

BGA	Ball grid array. A package type, defined by a resin-fiber substrate, onto which a die is mounted, bonded and encapsulated in molding compound. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
ICH6	I/O Controller Hub. The chipset component that contains the primary PCI interface, LPC interface, USB2, ATA-100, and other I/O functions. It communicates with the MCH over a proprietary interconnect called Direct Media Interface (DMI).
MCH	Memory Controller Hub. The chipset component that contains the processor interface, the memory interface, and the DMI.
T_{case_max}	Maximum die temperature allowed. This temperature is measured at the geometric center of the top of the package die.
T_{case_min}	Minimum die temperature allowed. This temperature is measured at the geometric center of the top of the package die.
TDP	Thermal design power. Thermal solutions should be designed to dissipate this target power level. TDP is not the maximum power that the chipset can dissipate.

1.2 Reference Documents

The reader of this specification should also be familiar with material and concepts presented in the following documents:

Document Title	Document Number / Location
Intel® I/O Controller Hub 6 (ICH6) Family Thermal Design Guide	http://developer.intel.com/design/chipsets/designex/302362.htm
Intel® I/O Controller Hub 6 (ICH6) Family Datasheet	http://developer.intel.com/design/chipsets/datashts/301473.htm
Intel® 925X Express Chipset Datasheet	http://developer.intel.com/design/chipsets/datashts/301464.htm
Intel® Pentium® 4 Processor on 90 nm Process in the 775-Land LGA Package Thermal and Mechanical Design Guidelines	http://developer.intel.com/design/Pentium4/guides/302553.htm
Intel® Pentium® 4 Processor 560, 550, 540, 530 and 520$^{\Delta}$ Datasheet	http://developer.intel.com/design/pentium4/datashts/302351.htm
Intel® 865G/865GV/865PE/865P Chipset: Intel® 82865G/82865GV GMCH and Intel® 82865PE/82865P MCH Thermal Design Guide	http://developer.intel.com/design/chipsets/designex/252519.htm
BGA/OLGA Assembly Development Guide	Contact your Intel Field Sales Representative
Various system thermal design suggestions	http://www.formfactors.org

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2 Packaging Technology

The Intel 925X/925XE Express chipset consists of two individual components: the 82925X/82925XE MCH and the Intel I/O Controller Hub 6 (ICH6). The MCH component uses a 37.5 mm squared, 6-layer flip chip ball grid array (FC-BGA) package (see Figure 2-1 through Figure 2-3). For information on the ICH6 package, refer to the *Intel® I/O Controller Hub 6 (ICH6) Family Thermal Design Guide.*

Figure 2-1. MCH Package Dimensions (Top View)

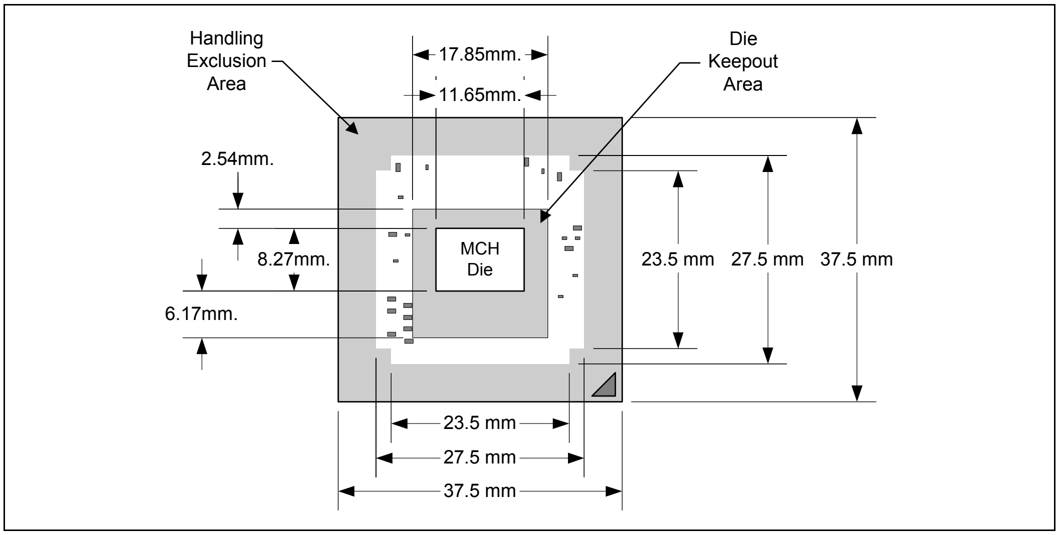
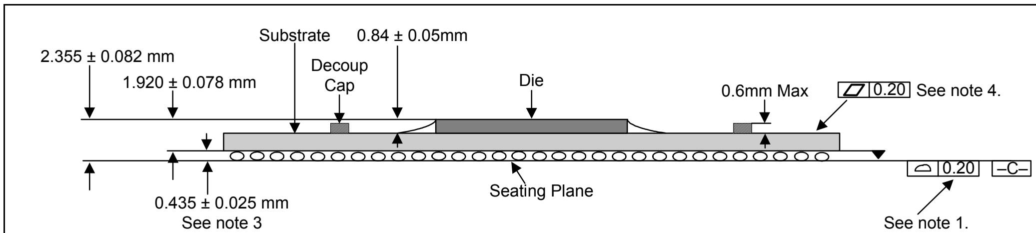
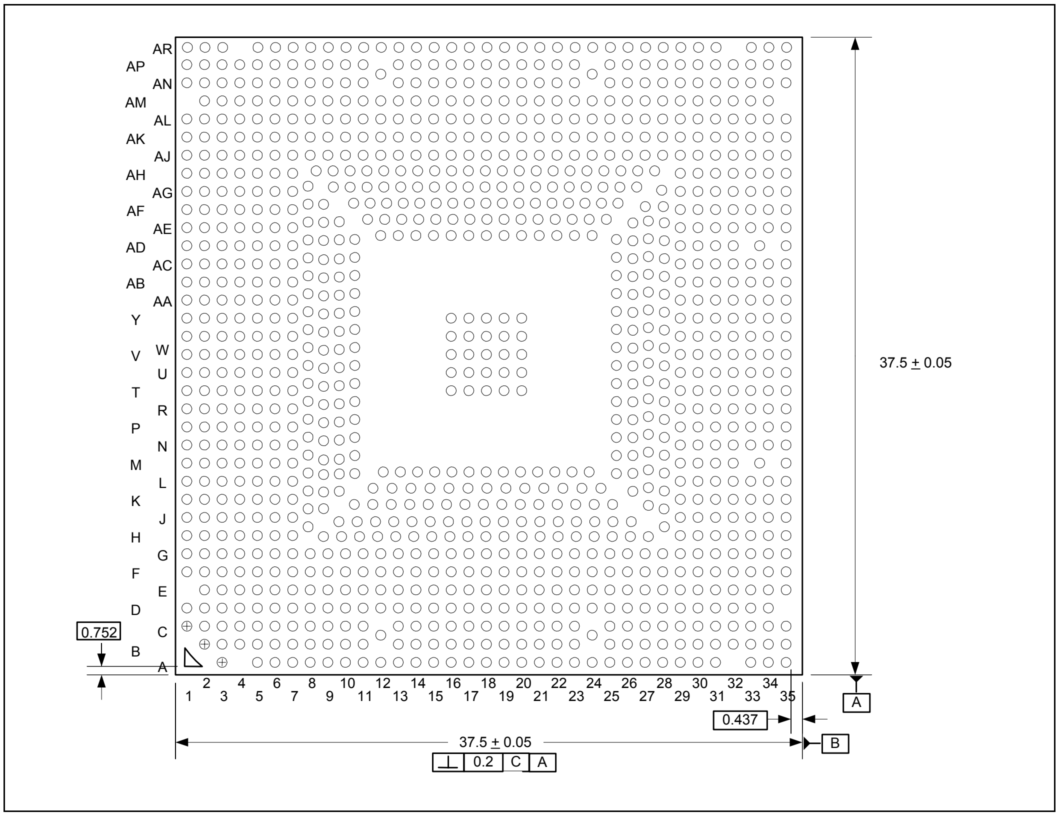


Figure 2-2. MCH Package Dimensions (Side View)



Notes:
1. Primary datum -C- and seating plan are defined by the spherical crowns of the solder balls (shown before motherboard attach)
2. All dimensions and tolerances conform to ANSI Y14.5M-1994
3. BGA has a pre-SMT height of 0.5mm and post-SMT height of 0.41-0.46mm
4. Shown before motherboard attach; FCBGA has a convex (dome shaped) orientation before reflow and is expected to have a slightly concave (bowl shaped) orientation after reflow

Figure 2-3. MCH Package Dimensions (Bottom View)



NOTES:

1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M-1994.

2.1 Package Mechanical Requirements

The MCH package has an exposed bare die that has mechanical load limits that should not be exceeded during heatsink installation, mechanical stress testing, and/or standard shipping conditions. The package is capable of sustaining a maximum static normal load of 15-lbf. The package is NOT capable of sustaining a dynamic or static compressive load applied to any edge of the bare die.

Note:

1. These mechanical load limits should not be exceeded during heatsink assembly, mechanical stress testing, or standard drop and shipping conditions. The heatsink attach solutions must not include continuous stress onto the MCH package with the exception of a uniform load to maintain the heatsink-to-package thermal interface.
2. These specifications apply to uniform compressive loading in a direction perpendicular to the bare die/IHS top surface.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.

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3 Thermal Specifications

3.1 Thermal Design Power (TDP)

For TDP specifications for the MCH, see Table 3-1. FC-BGA packages have poor heat transfer capability into the board and have minimal thermal capability without a thermal solution. Intel recommends that system designers plan for one or more heatsinks when using the Intel 925X/925XE Express chipset.

3.2 Die Case Temperature Specifications

To ensure proper operation and reliability of the MCH, the die temperatures must be at or between the operating range values specified in Table 3-1 for the 82925X MCH and Table 3-2 for the 82925XE MCH. System and/or component level thermal solutions are required to maintain these temperature specifications. Refer to Chapter 5 for guidelines on accurately measuring package die temperatures.

Table 3-1. Intel® 82925X MCH Thermal Specifications

Parameter	Value	Notes
T_{case_max}	105 °C	—
T_{case_min}	5 °C	—
$TDP_{dual\ channel}$	11.4 W	DDR2-400
$TDP_{dual\ channel}$	12.3 W	DDR2-533

NOTE: These specifications are based on silicon characterization; however, they may be updated as further data becomes available.

Table 3-2. Intel® 82925XE MCH Thermal Specifications

Parameter	Value	Notes
T_{case_max}	105 °C	—
T_{case_min}	5 °C	—
$TDP_{dual\ channel}$	12.5 W	DDR2-400
$TDP_{dual\ channel}$	13.3 W	DDR2-533

NOTE: These specifications are based on silicon characterization; however, they may be updated as further data becomes available.

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4 Thermal Simulation

Intel provides thermal simulation models of the 82925X/82925XE MCH and associated user's guides to aid system designers in simulating, analyzing, and optimizing their thermal solutions in an integrated, system-level environment. The models are for use with the commercially available Computational Fluid Dynamics (CFD)-based thermal analysis tool “FLOTHERM”* (version 3.1 or higher) by Flomerics, Inc. Contact your Intel field sales representative to order the thermal models and user's guides.

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5 Thermal Metrology

The system designer must make temperature measurements to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques to measure the MCH die temperatures. Section 5.1 provides guidelines on how to accurately measure the MCH die temperatures. The flowchart in Figure 5-1 offers useful guidelines for thermal performance and evaluation.

5.1 Die Case Temperature Measurements

To ensure functionality and reliability, the T_{case} of the MCH must be maintained at or between the maximum/minimum operating range of the temperature specification as noted in Table 3-1. . The surface temperature at the geometric center of the die corresponds to T_{case}. Measuring T_{case} requires special care to ensure an accurate temperature measurement.

Temperature differences between the temperature of a surface and the surrounding local ambient air can introduce errors in the measurements. The measurement errors could be due to a poor thermal contact between the thermocouple junction and the surface of the package, heat loss by radiation and/or convection, conduction through thermocouple leads, and/or contact between the thermocouple cement and the heatsink base (if a heatsink is used). For maximum measurement accuracy, only the 0° thermocouple attach approach is recommended.

5.1.1 Zero Degree Angle Attach Methodology

1. Mill a 3.3 mm (0.13 in.) diameter and 1.5 mm (0.06 in.) deep hole centered on the bottom of the heatsink base.
2. Mill a 1.3 mm (0.05 in.) wide and 0.5 mm (0.02 in.) deep slot from the centered hole to one edge of the heatsink. The slot should be parallel to the heatsink fins (see
3. Figure 5-2).
4. Attach thermal interface material (TIM) to the bottom of the heatsink base.
5. Cut out portions of the TIM to make room for the thermocouple wire and bead. The cutouts should match the slot and hole milled into the heatsink base.
6. Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the die using a high thermal conductivity cement. During this step, ensure no contact is present between the thermocouple cement and the heatsink base because any contact will affect the thermocouple reading. **It is critical that the thermocouple bead makes contact with the die** (see
7. Figure 5-3).
8. Attach heatsink assembly to the MCH and route thermocouple wires out through the milled slot.

Figure 5-1. Thermal Solution Decision Flowchart

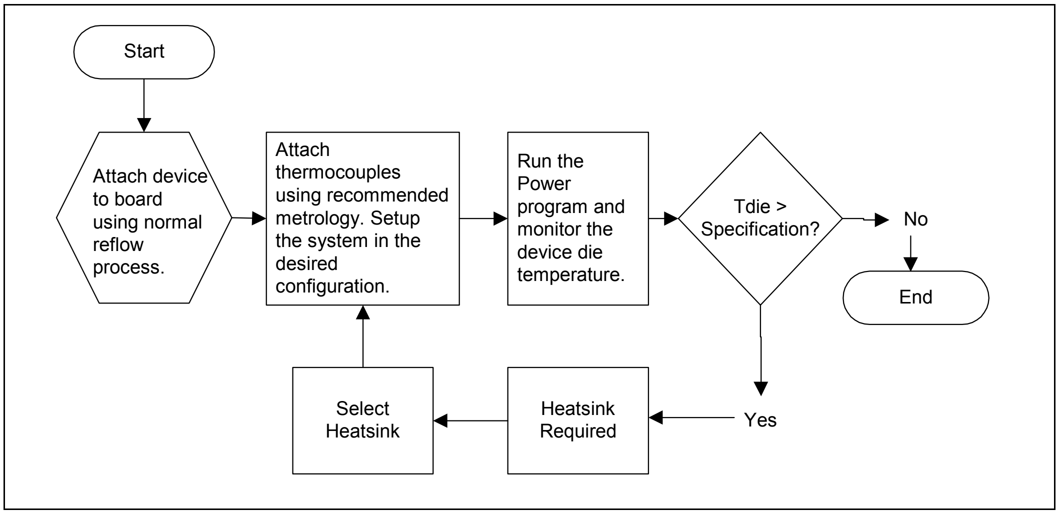


Figure 5-2. Zero Degree Angle Attach Methodology

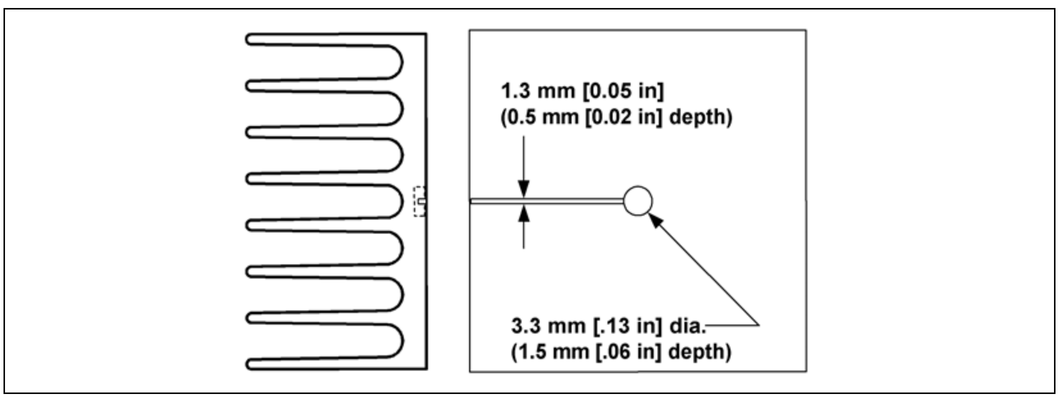
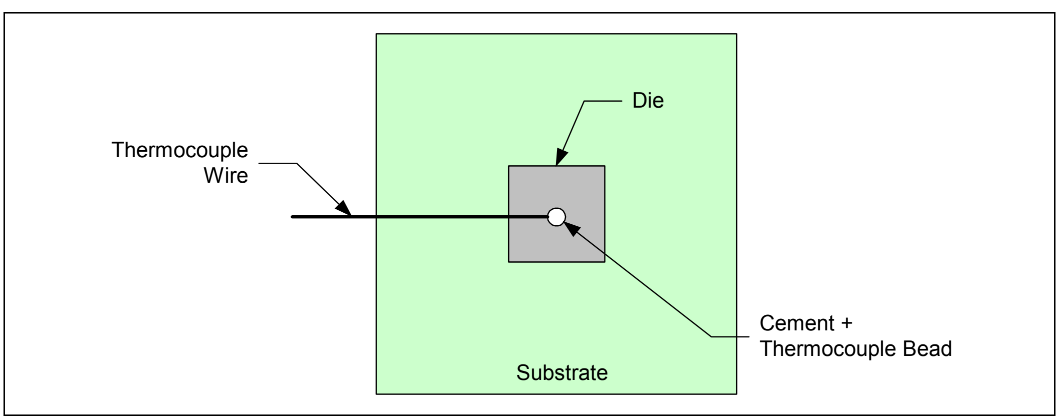


Figure 5-3. Zero Degree Angle Attach Methodology (Top View)



NOTE: Not to scale.

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6 Reference Thermal Solution

Intel has developed a reference thermal solution designed to meet the cooling needs of the MCH under worst-case condition. This chapter describes the overall requirements for the wave solder heatsink (WSHS) reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria. For manufacturing related information associated with this reference thermal solution, refer to thermal solution assembly section in the *Intel®* 865G/865GV/865PE/865P *Chipset Thermal Design Guide*. Other chipset components may or may not need attached thermal solutions, depending on your specific system local-ambient operating conditions. For information on the ICH6, refer to thermal specification in the *Intel® I/O Controller Hub 6 (ICH6) Family Thermal Design Guide*.

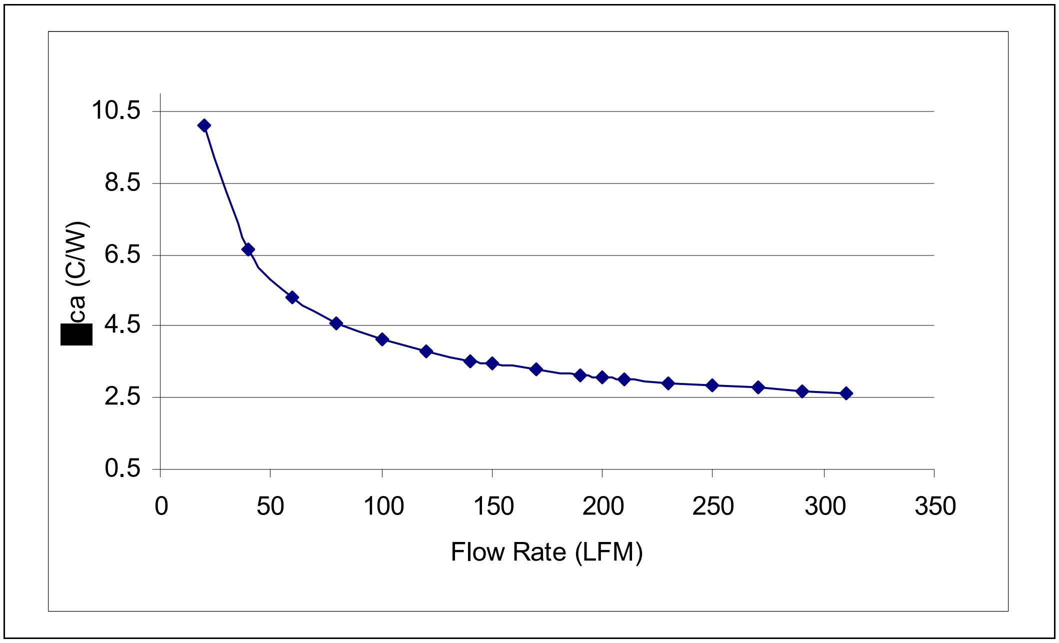
6.1 Operating Environment

The reference thermal solution was designed assuming a maximum local-ambient temperature of 47°C. The minimum recommended airflow velocity through the cross section of the heatsink fins is 200 linear feet per minute (lfm). The approaching airflow temperature is assumed to be equal to the local-ambient temperature. The thermal designer must carefully select the location to measure airflow to obtain an accurate estimate. These local-ambient conditions are based on a 35°C external-ambient temperature at sea level. (External-ambient refers to the environment external to the system.)

6.2 Heatsink Performance

Figure 6-1 depicts the measured thermal performance of the reference thermal solution versus approach velocity. Since this data was measured at sea level, a correction factor would be required to estimate thermal performance at other altitudes.

Figure 6-1. Reference Heatsink Measured Thermal Performance versus Approach Velocity

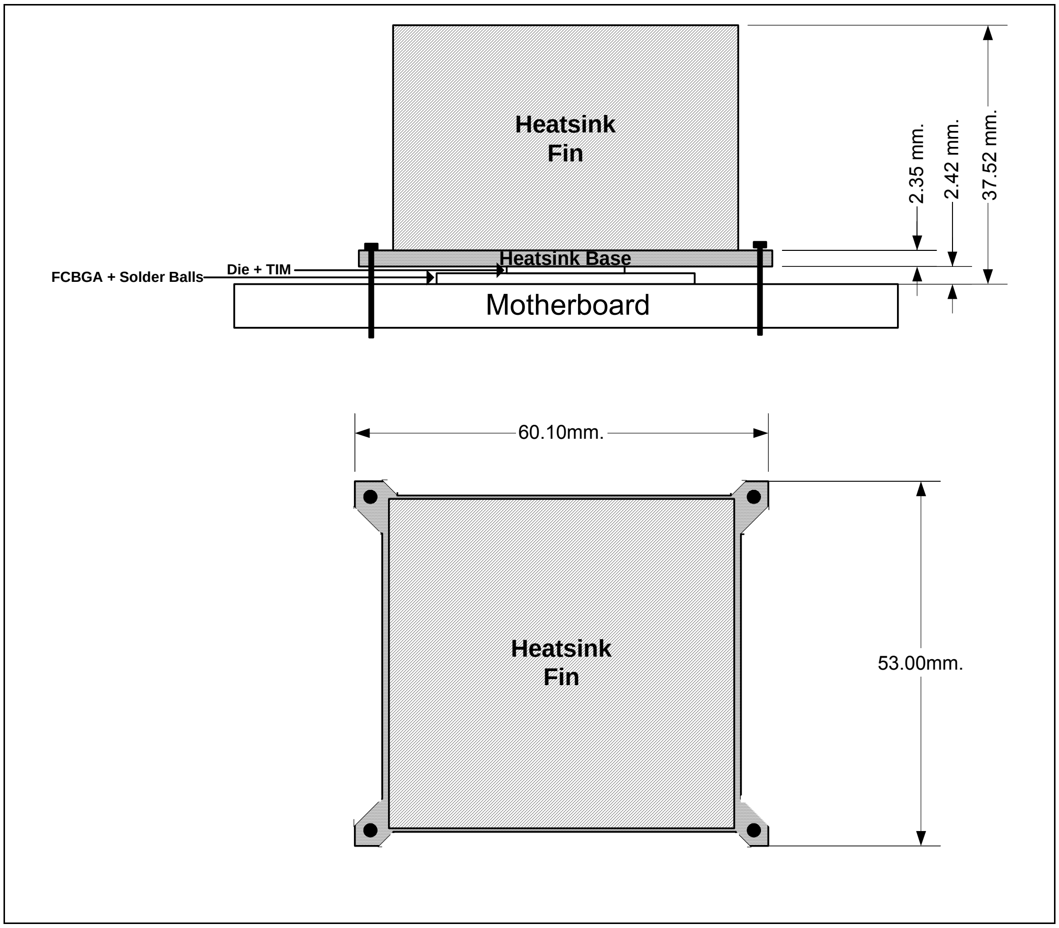


6.3 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the MCH thermal solution are shown in Figure 6-2.

When using heatsinks that extend beyond the MCH reference heatsink envelope shown in Figure 6-2, any motherboard components placed between the heatsink and motherboard cannot exceed 2.2 mm (0.087 in.) in height.

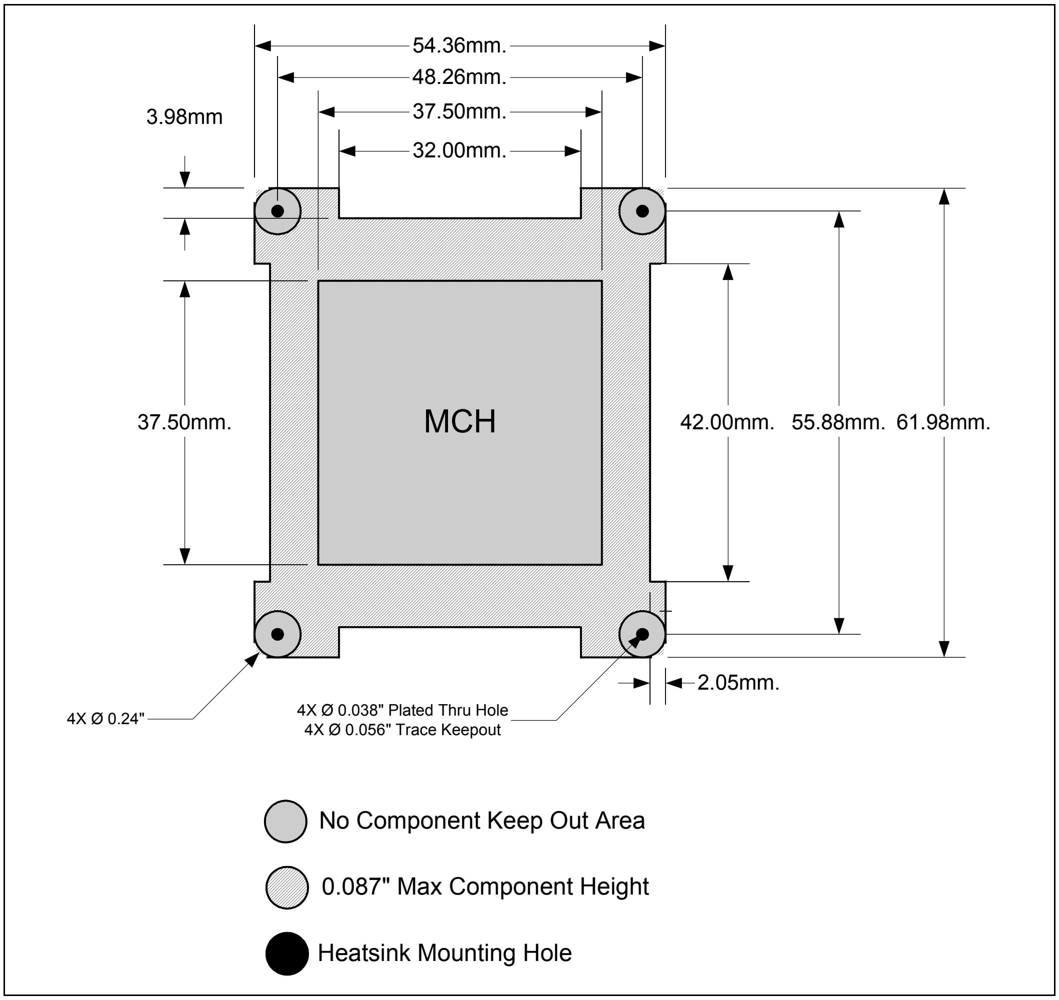
Figure 6-2. Heatsink Volumetric Envelope for the Intel® 82925X/82925XE MCH



6.4 Board-Level Components Keep-out Dimensions

The location of hole patterns and keep-out zones for the reference thermal solution are shown in Figure 6-3.

Figure 6-3. MCH Heatsink Board Component Keep-out



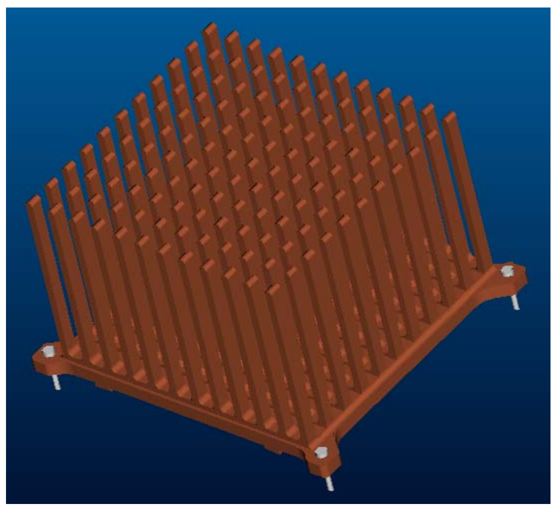
6.5 MCH Heatsink Thermal Solution Assembly

The reference thermal solution consists of a passively cooled WSHS. The heatsink consists of an extruded aluminum heatsink with four mounting pins pressed into each corner of the heatsink base. A TIM (Chomerics T-710*) is pre-applied to the heatsink bottom over an area in contact with the package die. A straight cut is performed on the heatsink base to create rails to reduce the possibility of tilt when assembling the WSHS.

Note: The rails do not touch the package substrate in the nominal position. The WSHS is shown in the installed configuration in Figure 6-4. (The MCH cannot be seen in this view as it is hidden by the WSHS base).

Full mechanical drawings of the thermal solution assembly and the mounting pins are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

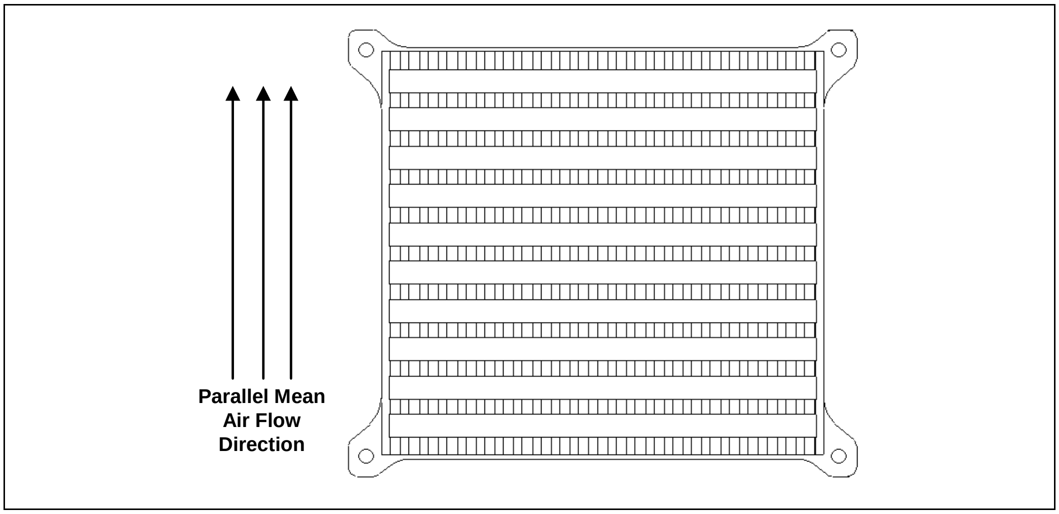
Figure 6-4. Wave Solder Heatsink Assembly



6.5.1 Heatsink Orientation

To enhance the efficiency of the reference thermal solution, it is important for the designer to orient the fins properly with respect to the mean airflow direction. Simulation and experimental evidence have shown that the MCH heatsink thermal performance is enhanced when the fins are aligned with the mean airflow direction (see Figure 6-5).

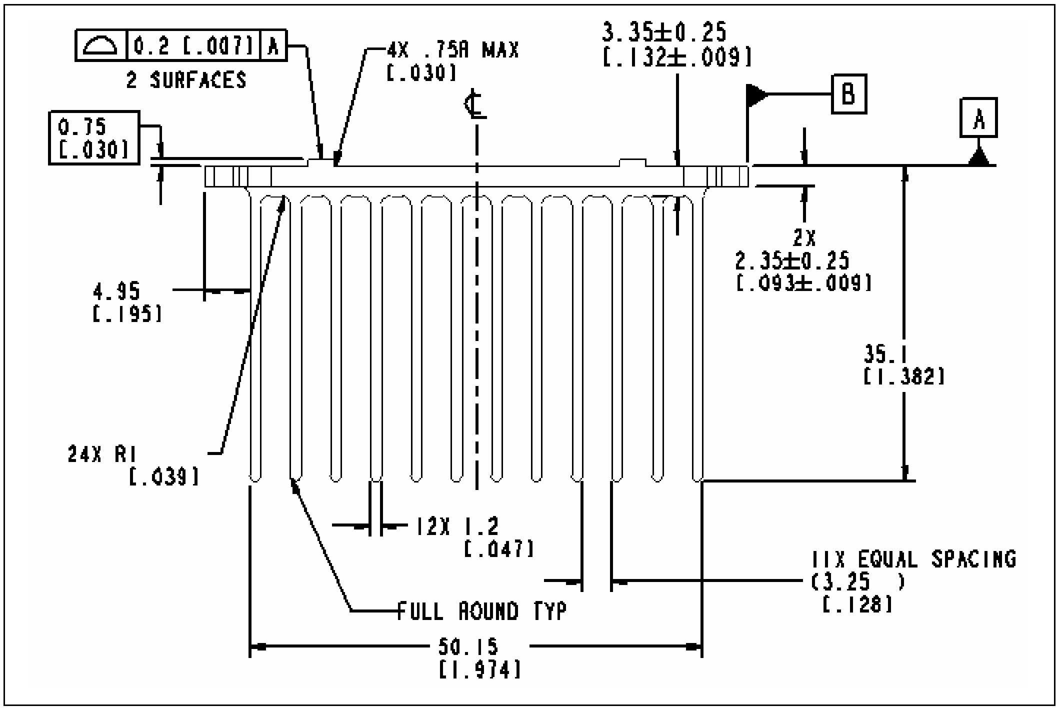
Figure 6-5. Preferred Heatsink Orientation



6.5.2 Extruded Heatsink Profiles

The reference thermal solution uses an extruded heatsink for cooling the MCH. Figure 6-6 shows the heatsink profile. This document does not provide tolerance information. Check with your heatsink supplier for specific tolerances. Appendix A lists suppliers for the extruded heatsink. Contact your heatsink supplier for information on alternate heatsinks.

Figure 6-6. Wave Solder Heatsink Extrusion Profile



NOTE: All dimensions are in millimeters, with dimensions in braces expressed in inches.

6.5.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

6.5.4 Thermal Interface Material

A TIM provides improved conductivity between the die and heatsink. The reference thermal solution uses Chomerics T-710, 0.127 mm (0.005 in.) thick, 19 mm x 19 mm (0.75 in. x 0.75 in.) square.

Note: Unflowed or “dry” Chomerics T710 has a material thickness of 0.005 inch. The flowed or “wet” Chomerics T710 has a material thickness of 0.0025 inches after it reaches its phase change temperature.

6.5.5 Heatsink Clip

There is no heatsink clip associated with this reference solution.

6.5.6 Clip Retention Anchors

There are no clip retention anchors associated with this reference solution.

6.6 Reliability Guidelines

Each motherboard, heatsink and attach combination may vary the mechanical loading of the component. Based on the end user environment, the user should define the appropriate reliability test criteria and carefully evaluate the completed assembly prior to use in high volume. Some general recommendations are shown in Table 6-1.

Table 6-1. Reliability Guidelines

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	50 g, board level, 11 msec, 3 shocks/axis.	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 min/axis, 50 Hz to 2000 Hz.	Visual Check and Electrical Functional Test
Temperature Life	85 °C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours.	Visual Check
Thermal Cycling	–5 °C to +70 °C, 500 cycles.	Visual Check
Humidity	85% relative humidity, 55 °C, 1000 hours.	Visual Check

NOTES:
1. It is recommended that the above tests be performed on a sample size of at least twelve assemblies from three lots of material.
2. Additional pass/fail criteria may be added at the discretion of the user.

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7 Appendix A: Thermal Solution Component Suppliers

Table 7-1. MCH Heatsink Thermal Solution

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Heatsink Assembly includes: • Pin Fin Heatsink • Solder Pin • Thermal Interface Material	C45196-001	CCI/ACK	Harry Lin (USA) 714-739-5797 hlinack@aol.com Monica Chih (Taiwan) (866) 2-29952666, x131 monica_chih@ccic.com.tw
		Foxconn	Kevin Tao (USA) 714-626-1278 kevintao@foxconn.com Cheow-Kooi Lee (Malaysia) (60) 4-6122122 leeck@foxconn.com
Pin Fin Heatsink (No Solder Pin)	C44761-001	CCI/ACK	Harry Lin (USA) 714-739-5797 hlinack@aol.com Monica Chih (Taiwan) (866) 2-29952666, x131 monica_chih@ccic.com.tw
		Foxconn	Kevin Tao (USA) 714-626-1278 kevintao@foxconn.com Cheow-Kooi Lee (Malaysia) (60) 4-6122122 leeck@foxconn.com
Solder Pin	C45195-001	CCI/ACK	Harry Lin (USA) 714-739-5797 hlinack@aol.com Monica Chih (Taiwan) (866) 2-29952666, x131 monica_chih@ccic.com.tw
		Foxconn	Kevin Tao (USA) 714-626-1278 kevintao@foxconn.com Cheow-Kooi Lee (Malaysia) (60) 4-6122122 leeck@foxconn.com

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Thermal Interface (T-710)	–	Chomerics* (69-12-22350-T710)	Todd Sousa (USA) 360-606-8171 tsousa@parker.com

NOTE: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.

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8 Appendix B: Mechanical Drawings

Table 8-1 lists the mechanical drawings included in this appendix.

Table 8-1. Mechanical Drawing List

Drawing Description	Figure Number
MCH Solder Heatsink Assembly Drawing	Figure 8-1
MCH Solder Heatsink Drawing	Figure 8-2
MCH Heatsink Mounting Pin Drawing	Figure 8-3

Figure 8-1. MCH Solder Heatsink Assembly Drawing

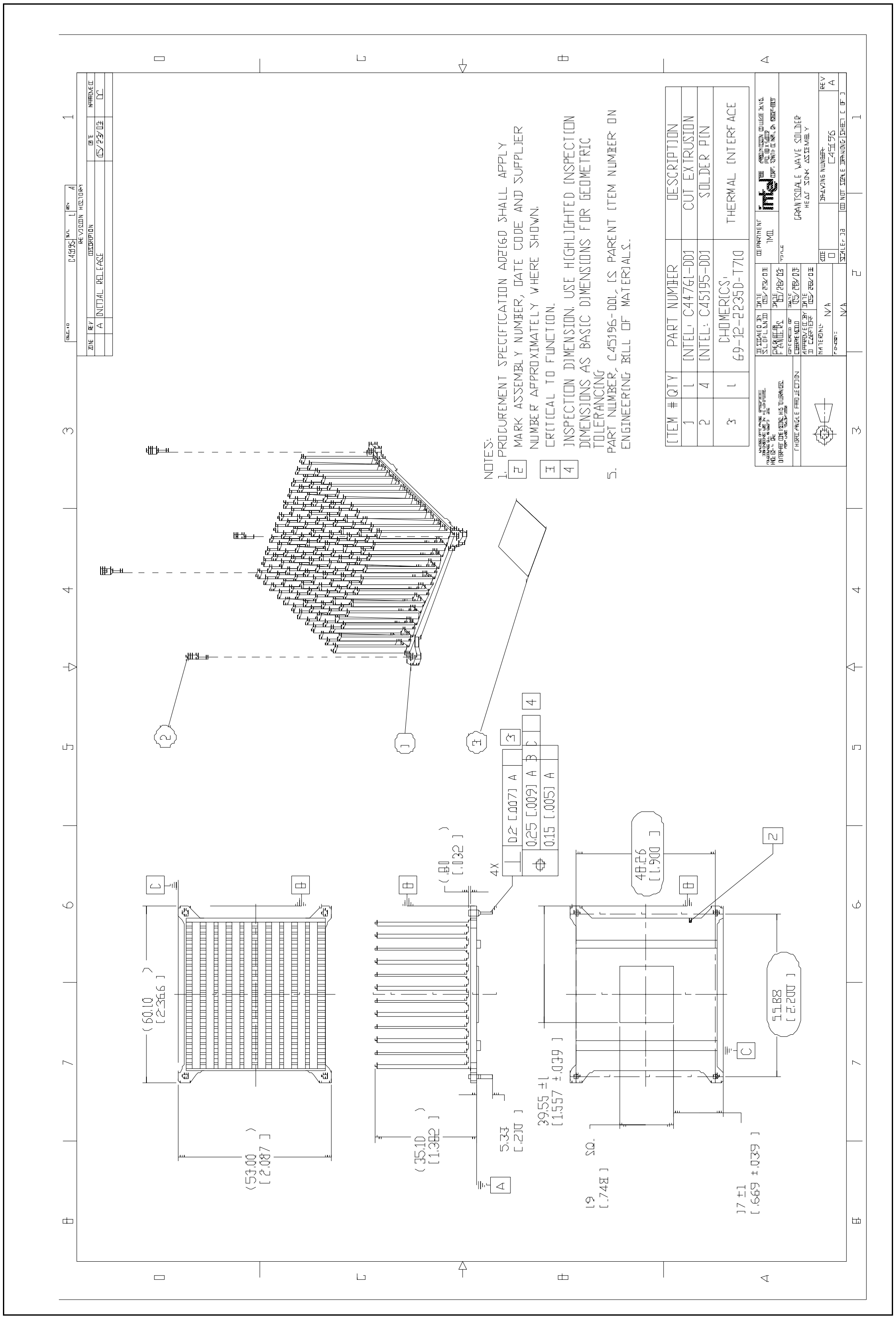


Figure 8-2. MCH Solder Heatsink Drawing

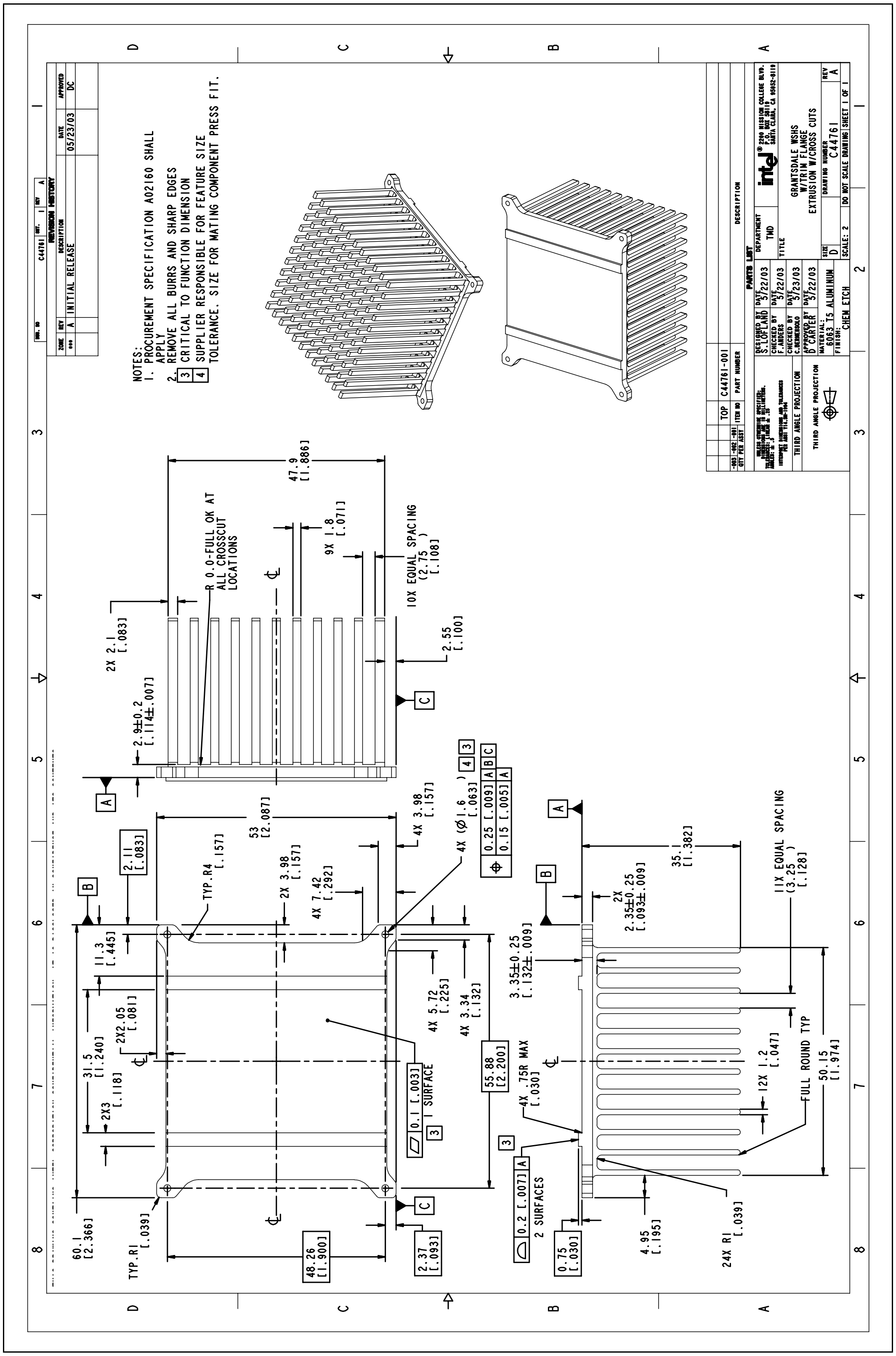
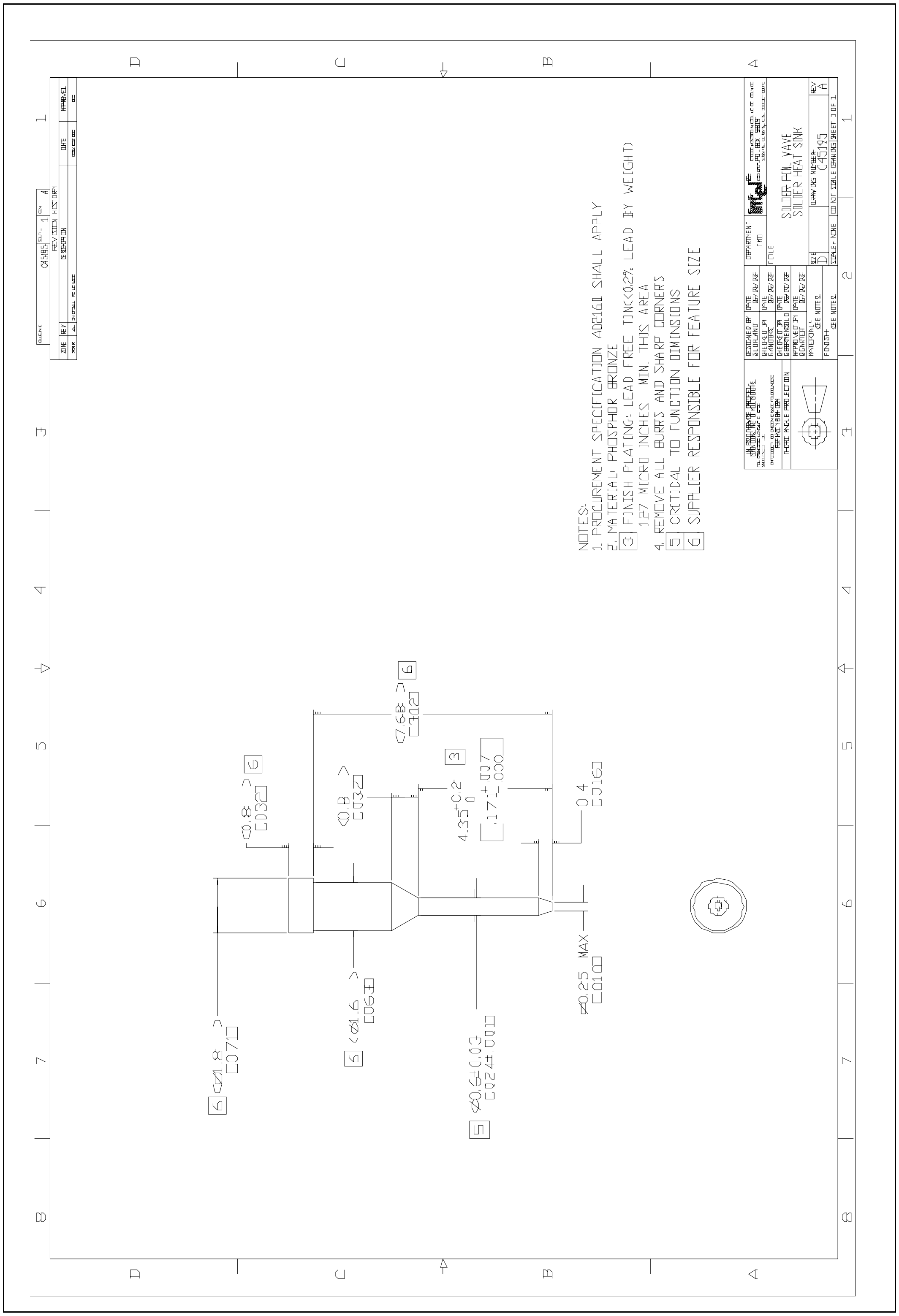


Figure 8-3. MCH Heatsink Mounting Pin Drawing



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